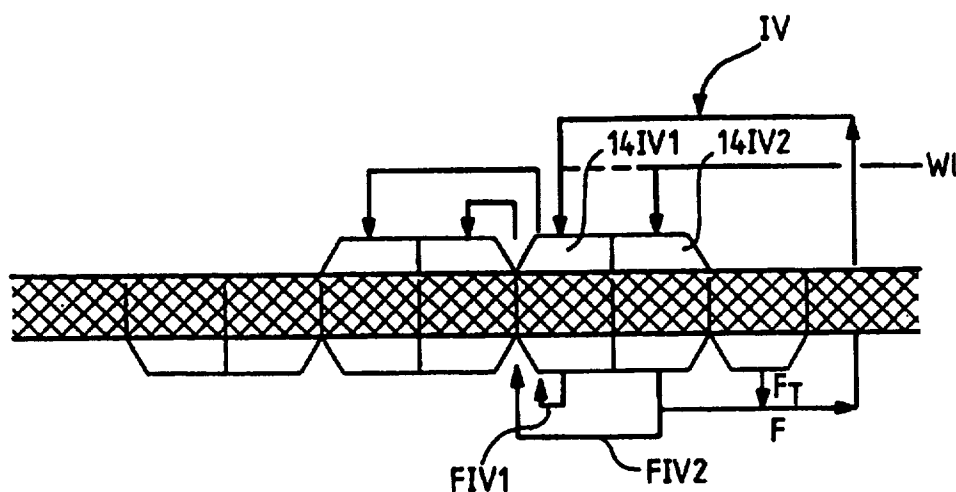




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<b>(21) International Application Number:</b> PCT/FI96/00316 <b>(22) International Filing Date:</b> 31 May 1996 (31.05.96)  <b>(30) Priority Data:</b> 954259                      11 September 1995 (11.09.95)      FI  <b>(71) Applicant (for all designated States except US):</b> AHLSTROM MACHINERY OY [FI/FI]; P.O. Box 5, FIN-00441 Helsinki (FI).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> QVINTUS, Harri [FI/FI]; Päiväkummunkaari 8 B, FIN-57230 Savonlinna (FI). TERVOLA, Pekka [FI/FI]; Munkkiniemen puistotie 21 B 19, FIN-00330 Helsinki (FI).  <b>(74) Agent:</b> AHLSTROM MACHINERY OY; Patent Dept., P.O. Box 18, FIN-48601 Karhula (FI).		<b>(81) Designated States:</b> AT, CA, CZ, FI, HU, JP, NO, PL, RU, SE, SK, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

**(54) Title:** SUPPLY OF WASHING LIQUID IN A FRACTIONATING MULTI-STAGE WASHER

**(57) Abstract**

The present invention relates to a method and an apparatus for intensifying washing of pulp in various washing apparatus. The method and apparatus of the invention are particularly well applicable in connection with the so-called Drum Displacer washers, DD washers, by A. Ahlstrom Corporation, and also in some wash presses. The method of effecting displacement wash of pulp, comprising feeding the pulp to be washed to a single-stage or a multi-stage washing system, washing the pulp therein and discharging the pulp from the system, and feeding wash liquid to the system, and discharging at least one filtrate from the system, is characterized in that at least a portion of the filtrate from a suction, press and/or thickening stage following the wash itself is guided to the preceding wash/washing stage to serve as wash liquid.

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## SUPPLY OF WASHING LIQUID IN A FRACTIONATING MULTI-STAGE WASHER

The present invention relates to a method of and apparatus for intensifying the washing of pulp with various washing apparatus. The method and apparatus are particularly well applicable in connection with the so-called Drum Displacer washers, DD washers, by A. AHLSTROM CORPORATION, and also in some wash presses. Because the method and apparatus of the invention are applicable in connection with other washing devices also, different apparatus used in washing are discussed here.

Several types of different washing apparatus and methods are known from the prior art. Diffusers, drum washers and belt washers clearly differ from each other. Pulp is supplied into washing diffusers at a consistency of approx. 10 %. The feeding consistency for drum and belt washers is most usually 1 - 3 %. Suction washers, wash presses and pressurized or super-atmospheric washers are examples of drum washers used today.

A conventional suction washer comprises a wire-covered drum revolving in a vat. The shell of the drum comprises under a perforated plate collecting compartments, and each compartment is connected with a tube of its own to a valve system on the shaft at the end of the drum. Filtrate from the valve is guided via a drop leg, or a centrifugal pump providing the required suction, for example to a filtrate tank. Due to the valve arrangement the influence of the drop leg may be directed appropriately in the desired spots of the web formation.

Web formation in a suction washer takes place as follows: inside the drum revolving in the vat, sub-atmospheric pressure sucking pulp suspension from the vat onto the surface of the drum has been arranged by means of a drop leg or some other device generating suction. When the

liquid passes through the drum the fibers in the pulp are collected onto the surface of the drum. The consistency of the suspension in the drum is approx. 0.5 - 2 % and the consistency of the layer thickened onto the drum surface is approx. 10 - 12 %. The web formation area, i.e. the portion of the drum periphery which is in the vat in the fiber suspension, is about 140 degrees. The maximum revolution velocity of the drum is 2 - 2.5 r/min; at higher revolutions speeds the filtrate collecting compartments and tubes do not have time to be emptied.

Washing is carried out as displacement wash by spraying wash liquid onto the surface of the drum which has risen up from the pulp vat. The sub-atmospheric pressure sucks the wash liquid through the pulp layer and displaces most of the liquid in the pulp. Thus, the displacement area is about 120 degrees. The typical specific square load of a suction washer is approx. 5 BDMT/m<sup>2</sup>/d and the thickness of the pulp web is of the order of 25 mm. In a bleaching plant, the square load of a suction washer is about 8 BDMT/m<sup>2</sup>/d and the web thickness about 30 mm.

A wash press comprises a drum covered with a wire or having a drilled perforated plate shell. Pulp is fed at a consistency of 3 - 4 % and knots and corresponding impurities must have been removed from the pulp prior to the washer. There are compartments provided in the shell of the drum from which filtrate is discharged via a chamber at an end periphery. Also, the drum may be open so that filtrate is collected inside the drum and is discharged via an opening at an end.

The length of the web formation stage is about 90 degrees and that of the displacement stage about 150 degrees. The revolution velocity of the drum is about 2 r/min and the specific square load about 15 - 20 BDMT/m<sup>2</sup>/d. The consistency of the washed web may rise even up to 35 %.

The displacement, however, takes place at a consistency of about 10 - 15 % while the thickness of the pulp web is about 30 - 50 mm.

5     An example of a superatmospheric pressure washer is a device disclosed in FI patent publications 71961 and 74752, which is composed mainly of a rotating drum and a stationary shell surrounding the drum. The drum is comprises a perforated cylinder the outer surface of  
10     which is provided with 50 - 60 mm high ribs at about 200 mm spacing. These ribs form with the perforated cylinder surface the so-called pulp compartments. There are filtrate compartments provided inside the cylinder under the pulp compartments, into which the filtrate displaced  
15     by the wash liquid is collected. There is a valve arrangement at the end of the cylinder drum substantially at the periphery of the diameter via which valve arrangement the filtrate is discharged and transported further. The washer comprises several, usually 3 - 4  
20     stages. This means that the wash liquid is reused many times for washing the pulp; thus, the filtrate collected in the filtrate compartments is guided countercurrent from one washing stage to another. Outside the washer drum, as a part of the washer shell, there are wash  
25     liquid feed chambers from which the wash liquid is pressed through the perforated plate to the pulp in the pulp compartments to displace the liquid in the pulp.

30     Web formation and washing of the pulp is carried out by supplying the pulp to be washed via a particular feed box to the pulp compartments. The feed box may thicken the pulp and axial "bars" of the same length as the drum are formed in the pulp compartments. Immediately after the feed point, there is the first washing zone on the drum;  
35     there are five separate washing zones in the apparatus described in the publications mentioned. A wash liquid flow is guided to each of these zones and the wash

liquid, while being pressed into the pulp layer in the compartments of the washing drum, displaces the liquid in the pulp. As already mentioned above, the filtrates are guided countercurrent from one zone to another. In other words, (cf. FI patent 74752, Fig. 1) clean wash liquid is pumped into the last washing stage and the filtrate displaced by this liquid is taken to the second last washing stage to serve as wash liquid. After the last washing stage, the "pulp bars" are detached from the drum, for example by blowing with pressurized air, and transported further on a transport screw.

The typical specific square load of a pressurized washer of this type with four stages is approx. 2.4 BDMT/m<sup>2</sup>/d. The thickness of the "pulp bar" is about 50 mm and the consistency may rise even up to 15 - 18 %. However, wash water leaking from the compartment decreases the consistency to 10 - 12 %. The consistency of the pulp fed onto the drum may vary between 3,5 and 10 %. The drum is rotated at about 0.5 - 3.0 rpm.

The FI patent 74752 mentioned above (corresponding US patents no. 4,919,158 and 5,116,423) and the appended Figure 2 illustrate schematically a little more advanced version of the basic approach of FI patent 71961, by means of which a remarkably better washing result is obtainable than with the basic arrangement illustrated schematically in the appended Fig. 1. In the embodiment of Figure 2, each washing stage has been divided into two zones so that two washing filtrates with different concentrations are obtained from each stage. These filtrates are recycled countercurrent as illustrated in the Figure. The figure illustrates also how the so-called suction filtrate, i.e. the filtrate extracted from the point between the last washing stage and the pulp discharge, is taken, with the washing filtrate from the latter washing zone of the last washing stage, to the

latter washing zone of the second last washing stage to be used as wash liquid.

5 It is typical of all the above apparatus that at least either the feed of the wash liquid or the treatment of the filtrates or both at the same time show drawbacks. These drawbacks may result in among other things poor washing result. If a washer is found not to be able to reach an adequate washing result the consequence  
10 naturally is that a washer with more washing stages or even a washer of a different type is acquired. It may also be necessary to try to solve the problem by increasing the consumption of clean wash liquid which increases the demand of steam in the evaporation plant  
15 and the capacity of waste water treatment equipment has to be increased and partly also environmental load increases.

20 The object of the invention is to solve the problems described above and to introduce arrangements applicable in many different washer types by means of which washing results are achieved which are very close to the optimal washing results obtainable with each washer or process type.

25 The characteristic features of the method and the apparatus are disclosed in the appended patent claims.

30 The method and the apparatus according to the invention is described below in detail by way of example with reference to the accompanying drawings of which

Fig. 1 illustrates schematically the operation principle of a prior art multi-stage washer;  
35 Fig. 2 illustrates schematically the operation principle of another prior art multi-stage washer;

Fig. 3 illustrates a preferred embodiment of the invention:

Fig. 4 illustrates another preferred embodiment of the invention:

5 Fig. 5 illustrates a conventional way of treating suction filtrate;

Fig. 6 illustrates a way according to a preferred embodiment of the invention, of using suction filtrate;

Fig. 7 illustrates a prior art wash press arrangement;

10 Fig. 8 illustrates a third preferred embodiment of the invention applied in a wash press arrangement;

Fig. 9 illustrates a prior art washing model;

Fig. 10 illustrates a washing model according to a fourth preferred embodiment of the invention;

15 Fig. 11 illustrates distribution of concentration of the filtrate as a function of the length of the fiber mat:

Fig. 12 illustrates a washing model according to a fifth preferred embodiment of the invention;

20 Fig. 13 illustrates a washing model according to a sixth preferred embodiment of the invention;

Fig. 14 illustrates a washing model according to a seventh preferred embodiment of the invention;

25 Fig. 15 illustrates the influence of the recycling of the suction filtrate and filtrate according to the invention on the purity of the pulp; and

Fig. 16 illustrates the influence of the recycling of the filtrate according to the invention on the purity of the pulp.

30 The operation principle illustrated schematically in Fig. 1 has been applied for example in the so-called DD washer according to FI patent 71961 by A. AHLSTROM CORPORATION. Figure 1 illustrates how pulp  $M_{in}$  is supplied onto the perforated and moving wire 10 of the apparatus. The wire  
35 may be cylindrical, a wash drum, or for example a plane-like surface, a belt washer. The wire 10 has been provided with baffles 12. Opposite the wire surface



surface 10, there are stationary wash water feed chambers 14 the bottoms 16 of which, together with the baffles 12 and the wire surface 10, form pulp washing compartments 18. Under the wire surface 10, there are a number of  
5 filtrate compartments 20 for collecting the filtrate displaced from the pulp by the wash water. The patent mentioned also describes more closely how the filtrate is transported further from the filtrate compartments 20 via a valve device provided at the end of the drum. The  
10 Figure shows that there are four washing stages I - IV in the apparatus. There are also corresponding wash liquid feed chambers  $14_I$ ,  $14_{II}$ ,  $14_{III}$  and  $14_{IV}$ , and filtrate compartments  $20_I$ ,  $20_{II}$ ,  $20_{III}$  and  $20_{IV}$ . It is typical of the operation of the apparatus that clean wash liquid  $W_I$   
15 is brought to the fourth washing stage IV, in which the pulp is cleanest. Filtrate  $F_{IV}$  from the fourth washing stage is brought to the third washing stage III to serve as wash liquid, and so on, until the filtrate  $F_I$  from the first washing stage is directed to waste water treatment,  
20 for example to an evaporation plant, and/or it is used as for dilution in a blow tower. As may be understood from the above, the apparatus is capable of replacing four conventional one-stage washers.

25 Figure 2 illustrates schematically a more advanced version of the same washer. This washer has been described more closely for example in US patents nos. 4,919,158 and 5,116,423. As the Figure shows, the washer still comprises four washing stages I - IV but each  
30 washing stage has been divided internally into two washing zones and filtrates of different concentrations are extracted from these zones. Thus, clean wash liquid  $W_I$  is brought to the fourth washing stage IV to displace filtrate from the pulp. Because of the fact that in the  
35 displacement washing of the type described the concentration of the liquid in the pulp decreases at a relatively even rate from the pulp feed  $M_{in}$  to the pulp

discharge  $M_{out}$ , the filtrate compartment  $20_{IV}$  of the fourth stage has been divided into two portions  $20_{IV1}$  and  $20_{IV2}$ , which thus collect filtrates  $F_{IV1}$  and  $F_{IV2}$  of different concentrations. Now these filtrates  $F_{IV1}$  and  $F_{IV2}$  are guided countercurrent, i.e. to the third washing stage III so that the cleanest filtrate, i.e. the filtrate  $F_{IV2}$ , from the latter zone of the fourth stage is guided to the feed chamber  $14_{III2}$  of the latter zone of the third stage III to serve as wash liquid. Correspondingly, the more fouled filtrate, i.e. the filtrate  $F_{IV1}$  from the former zone of the fourth stage, is directed to the feed chamber  $14_{III1}$  of the former zone of the stage III to be used as wash liquid. Continuing the process by this method to the end of the wash, pulp may be produced which is about 15 - 30 % cleaner than the one produced by the arrangement of Fig. 1.

Generally, it may be stated that the operation principle of a so-called fractionating multi-stage washer of this kind is to receive several filtrates from a washing stage or several washing stages and then to feed the filtrates to a previous washing stage to the zone having the same ordinal number, to be used as wash liquid. Thus, although a washer, in which each stage has been divided into two zones, has been described nothing prevents the stages from being divided into, for example, three zones whereby three different filtrates are received. Of course, it is also possible to divide separate stages into zones in a different way. In other words, for example only one filtrate may be extracted from a washing stage into which two or more wash liquids of different concentrations are supplied. In the so-called DD washer, the first washing stage is often of this kind; thus in some cases the filtrate from the first washing stage is extracted as one fraction to be transported for dilution of pulp and/or chemical recovery.

Figure 2 also illustrates how, as described in the patents mentioned, the so-called suction filtrate  $F_T$  obtained from between the last washing stage IV and the pulp discharge  $M_{OUT}$  is guided, with the cleaner filtrate  $F_{IV2}$  obtained from the fourth stage IV, to the feed chamber 14<sub>III2</sub> to be used as the wash liquid in the latter zone of the third stage III.

Further, according to the patents mentioned, the filtrates from the first washing stage I are combined,  $F_I$ , and are guided for example to an evaporation plant or to some other filtrate treatment. The US patents mentioned describe further that yet another filtrate may be obtained when feeding in pulp  $M_{in}$ ; this filtrate is discharged from the apparatus separately from the washing stage filtrate  $F_I$ .

When looking at the process closer, however, the filtrate treatment arrangement of FI patent 74752 or US patents 4,919,158 and 5,116,423 may be made more efficient. Between the last washing stage, which in this embodiment is the fourth washing stage IV, and the pulp discharge point  $M_{out}$ , so-called suction filtrate  $F_T$  is separated from the pulp which is used as wash liquid and referred to in the patents mentioned with reference number 27. The suction filtrate  $F_T$  comes mainly from the last filtrate compartment and possibly from the thickened pulp. Thus, the composition of the suction filtrate  $F^1$  resembles most the wash liquid  $W_1$  supplied to the washer.

Firstly, it should be noted that, if there is a suction filtrate flow  $F_T$  of the kind described, there is less wash liquid flowing into the last washing stage than to the remaining washing stages. Secondly, the suction filtrate  $F_T$  is cleaner than the pulp leaving the second last washing stage but only a little dirtier than the pulp discharged from the washing process, i.e. the washer.

Thus, in the arrangements of the patents mentioned, the fairly clean suction filtrate  $F_T$  is taken unnecessarily far upstream.

5 As illustrated in Fig. 3, the washing process may be made more efficient by supplying the suction filtrate  $F_T$  to the feed chamber  $14_{IV1}$  of the first zone of the last washing stage IV, and not to last zone of the second last washing stage III as described in the FI and US patents. The  
10 Figure illustrates how a portions of the filtrate  $F_{IV2}$  from the last zone of the last washing stage IV is extracted and combined with the suction filtrate  $F_T$  from the thickening stage and the mixture is supplied to the first zone of the last washing stage IV. The Figure also  
15 indicates with a broken line that clean wash water  $W_1$  may be supplied, not only to the feeding chamber  $14_{IV1}$  of the last zone of the last washing stage IV, but also to form a part of the wash liquid supplied to the feed chamber  $14_{IV1}$  of the first zone of the last washing stage IV. By  
20 arranging the circulation of the suction filtrate  $F_T$  in the way described above the volume of the wash liquid fed into the last washing stage IV and the suction filtrate  $F_T$  is used for one extra wash.

25 Another way of circulating the suction filtrate  $F_T$  is to feed it, combined with clean wash liquid  $W_1$ , to both the feed chambers,  $14_{IV1}$  and  $14_{IV2}$ , of the last washing stage IV as illustrated in Fig. 4.

30 It may also be understood that there is a further washing stage subsequent to the last washing stage IV and the suction filtrate  $F_T$  comes from this extra washing stage.

35 Performed tests have shown that the new way of circulating of the suction filtrate according to the invention increases the purity of the pulp by 5 - 35 % depending on the number of washing stages performed with

the washer. Naturally, the purity increase is the greater the fewer washing stages there are in the washer. In a conventional two-stage washer the washing result improves by about 15 - 35 %.

5

Figures 5 and 6 illustrate the effect of recirculating the suction filtrate in the liquid circulation of a one-stage washer. The numerals in the Figures represent the liquid flows, expressed in cubic meters, used for washing one ton of pulp (ADT; consistency 90 %, i.e. one ton of pulp contains 900 kg fibers and 100 kg liquid). Thus, pulp containing 9.1 cubic meters of liquid per one ton of pulp, consistency about 9 %, is introduced to the washing; during the web formation 2.5 tons of liquid is removed and the consistency in the washing process is about 13.5 %. From this, 1.5 cubic meters of suction filtrate is still removed in the suction stage and thus the discharge consistency of the pulp is about 17.6 %. Figure 5 illustrates a state-of-the-art one-stage washer in which the suction filtrate is combined with the filtrate from the web formation and the washing stage proper and is removed from the apparatus for further treatment of filtrates or for some other use.

Figure 6 illustrates a case in which the suction filtrate is directed to the beginning of the washing stage; thus, 1.5 cubic meters more of wash liquid per ton of pulp is supplied to the wash itself. As with these amounts the volume of wash liquid is relatively directly proportional to the washing result, it may be stated that in this kind of a case the washing result improves by about 20 %.

Figure 7 illustrates schematically a prior art pulp washing arrangement using a wash press. According to the arrangement of the Figure, pulp is brought for example from a digester or a blow tank of a digester to dilution 30 and diluted to a consistency of approx. 4 %. After

the dilution the pulp is taken to a thickener 32 in which the pulp is thickened to a consistency of about 10 - 15 %. The medium consistency pulp obtained is supplied to a displacement stage 34 into which clean wash liquid is supplied. The pulp is further taken to a thickening stage 38, in which liquid is removed from the pulp so as to raise the consistency to the range of 30 - 40 %. It is typical of the state-of-the-art wash press arrangements that the filtrates  $F_W$ ,  $F_{T1}$ , and  $F_{T2}$  obtained as well from the washing as from the preceding and subsequent thickening stages are combined irrespective of their different concentrations. A portion  $F_1$  of the filtrate mixture  $F$  obtained in this way is used in the dilution stage 30 to dilute pulp while the other portion  $F_2$  goes to chemical recovery or some other further use or treatment.

Figure 8 illustrates a wash press arrangement according to the invention the most significant difference of which compared to the arrangement of Fig. 5 is that the wash press includes two washing stages. The reference numerals used in Fig. 8 correspond to the ones used in Fig. 5; the second washing stage is referred to with numeral 38 and its filtrate with  $F_{W2}$ . When the two washing stages 34 and 36 have been connected the filtrates obtained from the system may be transported countercurrent so that the relatively clean filtrate  $F_{T2}$  from the last thickening stage 38 of the system is used as wash liquid in the first washing stage 34. Clean wash liquid  $W_1$  from an external source is brought only to the second washing stage 36.

It should be noted here that the dilution, thickening and displacement stages mentioned both in connection with Fig. 8 as well as with Figs. 9 and 10 may be carried out in one and the same apparatus or in separate apparatus located even quite far apart from each other. In

practise, the distance between the operations is not of as decisive importance as the method of carrying out the process. In other words, Figures 9 and 10 may illustrate for example a prior art washer connection and an improvement made therein. Thus, as in Fig. 9, for example the pulp  $M_{in}$  coming from a digester may be diluted to a low consistency for example in a blow tank 40 by using filtrate  $F_{TW}$  for this purpose, which may be for example a mixture of filtrate from a thickening stage of a DD washer by A. AHLSTROM CORPORATION, forming the "pulp bar" in the washing space and from a washing stage 44. However, the concentration of the filtrate of the thickening stage mentioned is the same as the concentration of the liquid remaining in the pulp, i.e. the concentration of the liquid used for the dilution has not been paid attention to previously. FI patent 74752, and US patents 4,919,158 and 5,116,423, however, show that the filtrates mentioned are taken separately. Further use or treatment of either of the filtrates is, however, not discussed.

Figure 10 illustrates a preferred embodiment of the invention improving the process described above. The arrangement of Fig. 9 has been changed so that washing stage filtrate  $F_W$  and a portion of the filtrate  $F_T$  from the thickening stage 42 are used for the dilution 40. The rest of the filtrate from the thickening stage 42 is guided to chemical recovery. An arrangement of this kind has been found to improve the washing result by 10 - 15 %. Of course the entire dilution may be carried out with washing stage filtrate if that suffices. In other words, previously filtrates from both the thickening and the washing stages were mixed with each other and after that a portion of this combined filtrate was used for dilution. According to the method of the present invention, only the amount of the filtrate from the thickening stage is taken to the dilution that falls

short from the filtrate from the displacement stage. When carried out the way described above the concentration of the filtrate used for the dilution is lower than that of the filtrate used in the prior art arrangement.

The methods described above may still be made more efficient by focusing on the typical concentration distribution of the filtrate which has been illustrated schematically in Figure 11 as a function of the mat length, i.e. the length of the washing stage. The Figure clearly indicates that the closer the end of the washing stage is the lower the concentration of the filtrate is, i.e. the cleaner the filtrate is. This means that filtrate may be taken from the end of the wash and used even at the beginning of the same washing stage.

Figures 12, 13 and 14 illustrate examples in connection with a single-stage washer of how 5 - 15 % of the displacement filtrate from the end part of a washing stage is taken to the beginning of the washing stage. In practise it is possible to bring greater volumes, i.e. a greater portion of the filtrate, to the beginning of the washing stage. Naturally, it is also possible to fractionate the filtrate to be recirculated, i.e. to extract filtrates of several different concentrations and to recirculate them at different points in the beginning of the washing stage, of course the most concentrated first.

Figure 15 illustrates comparison of the single-stage washer connections illustrated in Figures 5, 6, 12, 13 and 14. The horizontal scale depicts the percentage of solid material dissolved from the material, i.e. chemicals and fibers, which on principle should have been removed from the pulp but which the apparatus has not been able to remove. Thus, the scale in the Figure



illustrates the range in which 10 - 13 % of the "dirt" is still there. The vertical axis indicates the percentage of washing loss change. Washing losses here mean the amount of dissolved dry solids and chemicals remaining in the liquid in the pulp after the wash. The invention aims at diminishing these washing losses. The initial situation in Figure 15 is the connection illustrated in Fig. 5, according to which the suction filtrate is removed from the apparatus with other filtrates and it is not returned to the apparatus; thus the descriptor is the horizontal axis of the scale (notice the real zero point of the scale). The 0 % curve depicts the influence of the connection illustrated in Figure 6, i.e. an arrangement in which the entire suction filtrate is returned to the beginning of the washing stage but the filtrate from the displacement washing stage itself is left untouched. The 5 % curve depicts the influence of the connection illustrated in Figure 12, i.e. an arrangement in which 5 % of the displacement wash filtrate is recycled with the suction filtrate to the beginning of the washing stage. Correspondingly, the 10 % and the 15 % curves represent the effect of the arrangements illustrated in Figures 13 and 14. The Figure indicates that if pulp discharged from a conventional washing stage (Fig. 5) contains 11 % of the chemicals and the dissolved dry solids, this washing loss may be reduced by about 21 % by recycling the suction filtrate to the beginning of the washing stage. This means that the washing loss is reduced to 8.7 %. Correspondingly, if the suction filtrate mentioned and also 10 % of the displacement wash filtrate is recycled to the beginning of the washing stage the washing loss is reduced by about 30.5 %, i.e. the washing loss is reduced to about 7.6 %. Thus the washing loss is reduced from 8.69 to 7.645, which means about 12 %.

Figure 16 similarly shows a set of curves the initial situation of which is that the recycling of the suction filtrate has already been employed. By using this set of curves the situation with the first example of the  
5 previous Figure may be checked, in which the washing loss was 8.7 % and it was further reduced to 7.8 % by returning 10 % of the filtrate obtained from the end of the washing stage to the beginning of the wash. By choosing 8.7 % from the horizontal scale and coming down  
10 to the 10 % curve, the washing loss reduction may be seen to be about 12 % as already calculated above.

Recycling a part of the displacement filtrate as described above requires a filtrate compartment of its  
15 own to be provided, one way or another, at the end of the washing stage. A preferred way of effecting this is to use a movable sealing member to separate a part of the actual filtrate compartment so that the volume of the displacement filtrate to be separated may be varied by  
20 moving the sealing member. Thus, the volume of the filtrate recycled may be controlled for example according to the running situation of the washer.

As may be understood from the above, the present  
25 invention provides a way of making the washing processes of the wood processing industry remarkably more economical and environmentally more friendly compared to the prior art methods and apparatus. It should, however, be born in mind that the embodiments described above are  
30 only a few preferred alternative examples of applying the present invention and they do not in any way intend to limit the scope of protection of the invention from the one described in the appended patent claims. Thus, although only examples of single-stage washers have been  
35 described the operation of multi-stage washers may be made more efficient by corresponding means.

We claim:

1. A method of effecting displacement wash of pulp comprising feeding the pulp to be washed to a single-stage or a multi-stage washing system, washing the pulp therein and discharging the pulp from the system, and feeding wash liquid to the system, and discharging at least one filtrate from the system; **characterized** in that at least a portion of the filtrate from a suction, press and/or thickening stage following the wash itself is guided to the preceding wash/washing stage to serve as wash liquid.
2. A method as claimed in claim 1, **characterized** in that in a multi-stage fractionating wash at least a portion of the filtrate from a suction, press and/or thickening stage following the wash itself is guided to the first zone of the preceding wash/washing stage to serve as wash liquid.
3. A method as claimed in claim 1, **characterized** in that at least a portion of the filtrate mentioned, combined with clean wash liquid, is guided to the first zone of the preceding wash/washing stage to serve as wash liquid.
4. A method as claimed in claim 1, **characterized** in that at least a portion of the filtrate mentioned, combined with at least a portion of the filtrate obtained from the second/last zone of the preceding wash/washing stage, is guided to the first washing zone of the preceding wash/washing stage to serve as wash liquid.
5. A method as claimed in claim 1, **characterized** in that the washing stage is at least one-staged and fractionating so that at least two separate filtrates are obtainable from each stage.

6. A method as claimed in claim 1, **characterized** in that the washing stage is at least one-staged and fractionating so that at least two separate wash liquids are suppliable to each stage and that at least two  
5 separate filtrates are obtainable from each stage.

7. A method as claimed in claim 1, **characterized** in that filtrate obtained from the press or suction stage following the last two-zone or multi-zone washing stage  
10 is used in the zone preceding the zone using the wash liquid itself of the last washing stage, and that the wash liquid itself is used at the end of the last washing stage, i.e. in the last zone.

8. A method as claimed in claim 1, **characterized** in that the filtrate from the press or suction stage following a washing stage comprising at least one washing stage and one or several zones is used in the first zone of the  
15 last washing stage.

9. A method as claimed in claim 1, **characterized** in that the filtrate from the press or suction stage following a washing stage comprising at least one washing stage and one or several zones is used in the first zone of the  
20 last washing stage and the wash liquid itself is used at the end of the last washing stage.

10. A method as claimed in claim 1, **characterized** in that the washing system comprises at least one dilution stage, at least one displacement stage and at least one  
25 thickening stage, in that order.

11. A method as claimed in claim 10, **characterized** in that the washing system comprises at least one dilution stage, at least one thickening stage and at least one  
35 displacement stage and at least one thickening stage, in that order.

12. A method as claimed in claim 10 or 11, **characterized** in that the filtrate from at least one thickening stage following at least one displacement stage is used at least as a part of the wash liquid supplied to the beginning of the last washing stage.

13. A method as claimed in claim 10, 11 or 12, **characterized** in that the filtrate from at least one thickening stage following at least one displacement stage is used at least as a part of the wash liquid supplied to the beginning of the last washing stage.

14. A method as claimed in claim 1, **characterized** in that the washing system comprises a dilution stage, a first thickening stage, at least two washing stages and a second thickening stage, in this order.

15. A method as claimed in claim 14, **characterized** in that a portion of at least one of the filtrates obtained from one or several of said washing stages is used in said dilution stage to dilute the pulp.

16. A method as claimed in claim 14, **characterized** in that filtrate from said second thickening stage is used at least as a part of the wash liquid to be supplied to the first washing stage.

17. A method as claimed in claim 1, **characterized** in that the washing system comprises a dilution stage, a thickening stage and at least one washing stage, whereby at least a part of the filtrate from said washing stage is used in said dilution stage to dilute the pulp.

18. A method as claimed in claim 1, **characterized** in that a part of the filtrate from the only or the last stage of the wash is returned to the beginning of said stage to serve as the wash liquid.

19. An apparatus for effecting displacement wash of pulp, comprising a wire (10) having a first surface and a second surface, and wherein a web of the pulp to be washed has been formed onto said first surface; and means  
5 (20) for receiving filtrate and means for receiving so-called suction filtrate have been provided facing said second surface; and means (14) for feeding wash liquid onto the web, disposed on the same side of the wire as the first wire surface and the web, facing the means (20)  
10 receiving filtrate on the opposite side of the web, **characterized** by means with which at least a portion of the so-called suction filtrate is guided to be used for washing the pulp.

15 20. An apparatus as claimed in claim 19, further **characterized** by means of which a portion of the filtrate from the last washing stage is taken to be used as wash liquid in the same washing stage.

20 21. An apparatus as claimed in claim 19, **characterized** in that said means (20) for receiving filtrate include a movable sealing for controlling the volume of filtrate separated for use as wash liquid.

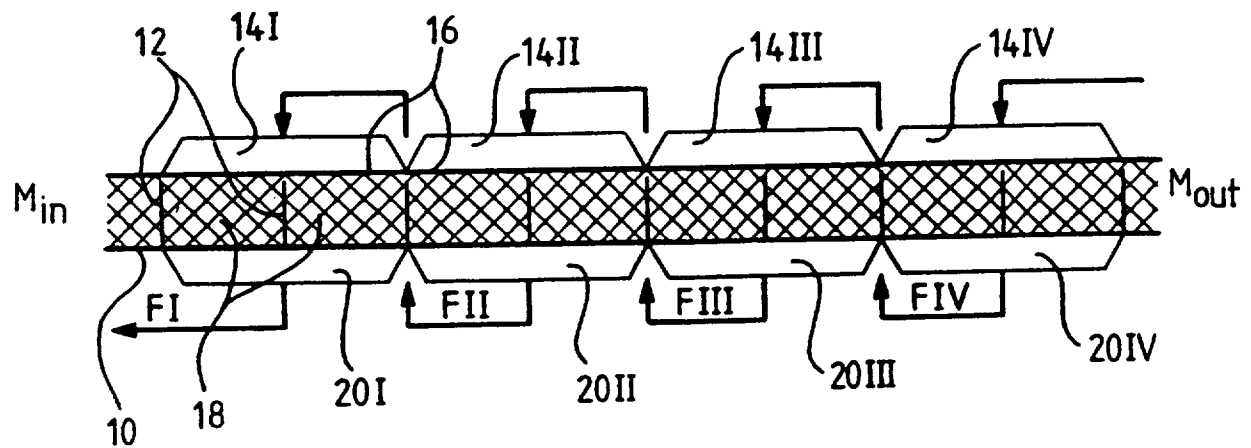


FIG. 1

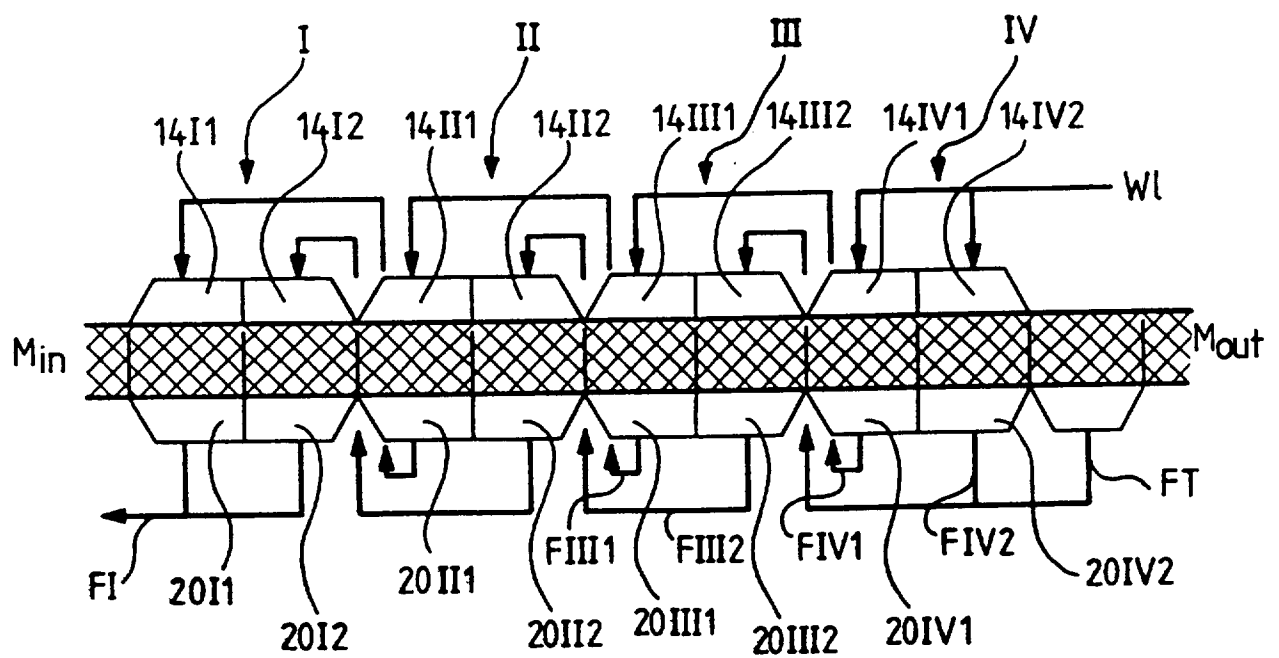


FIG. 2

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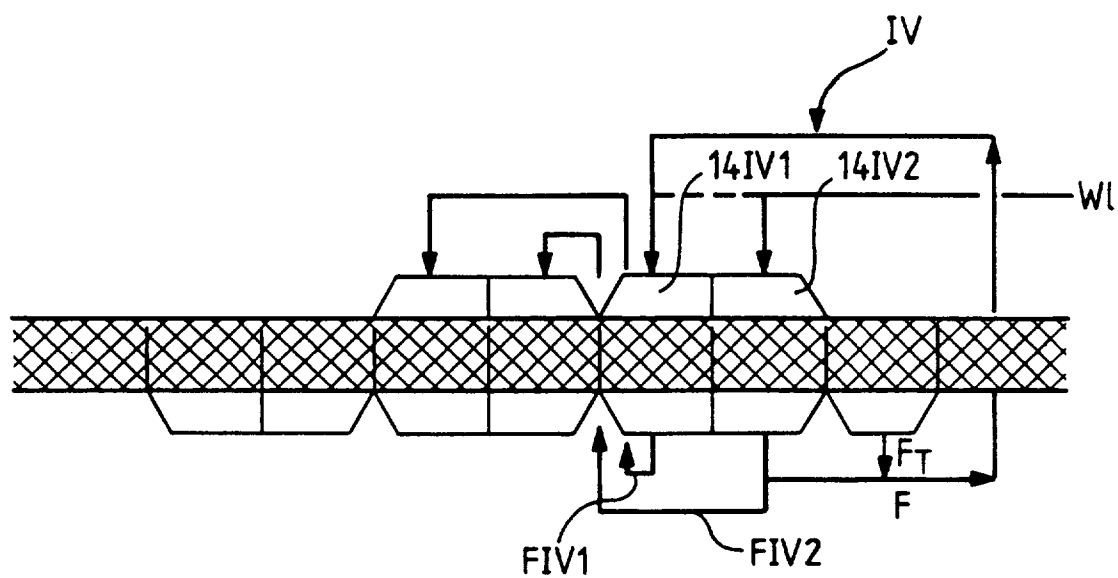


FIG. 3

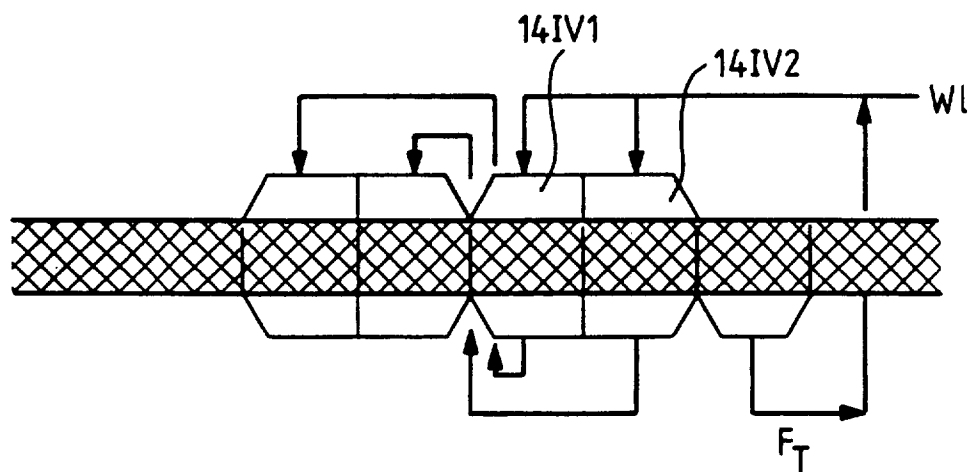


FIG. 4



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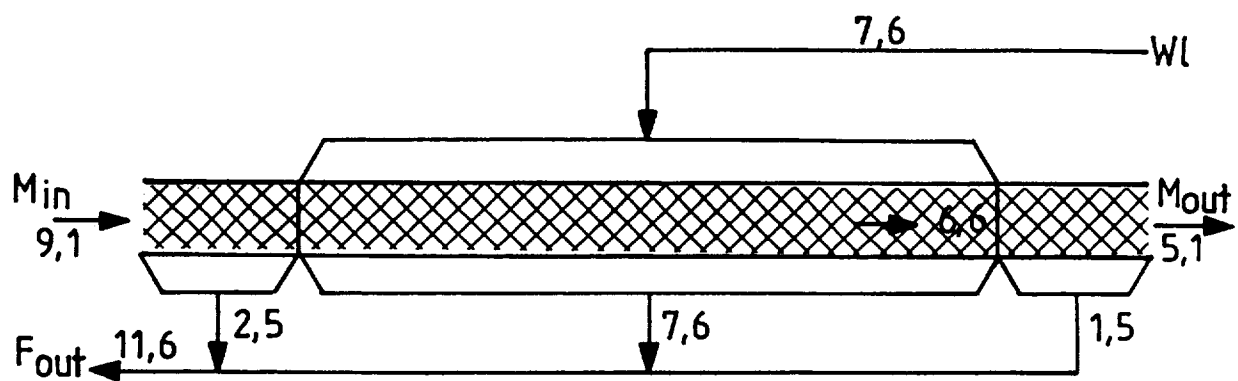


FIG. 5

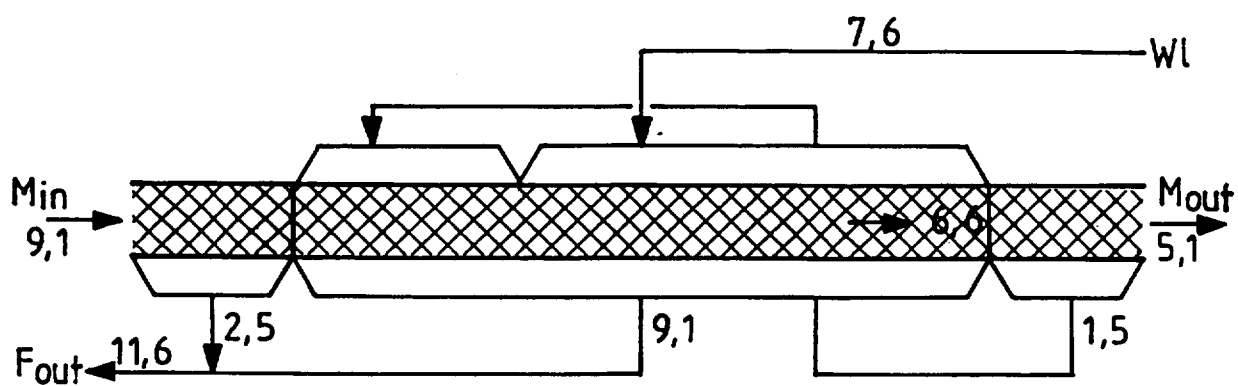


FIG. 6

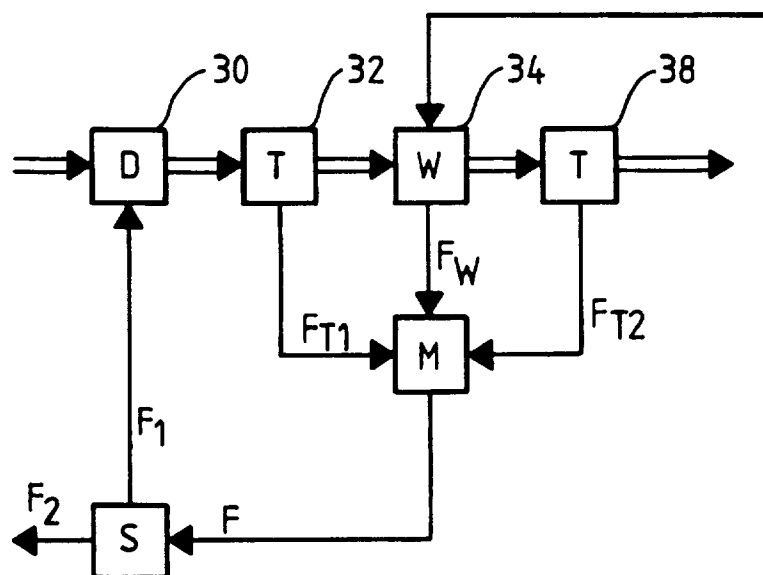


FIG. 7

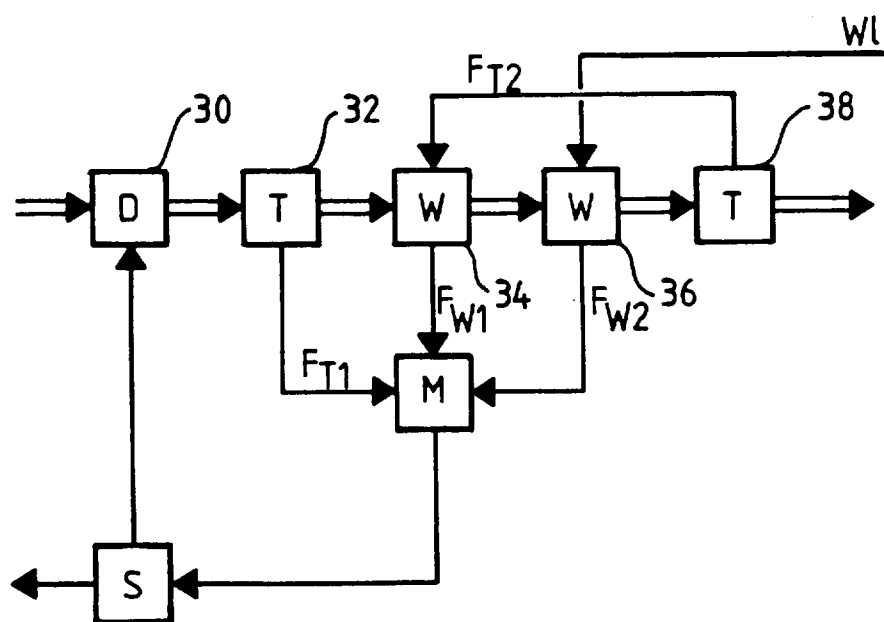


FIG. 8

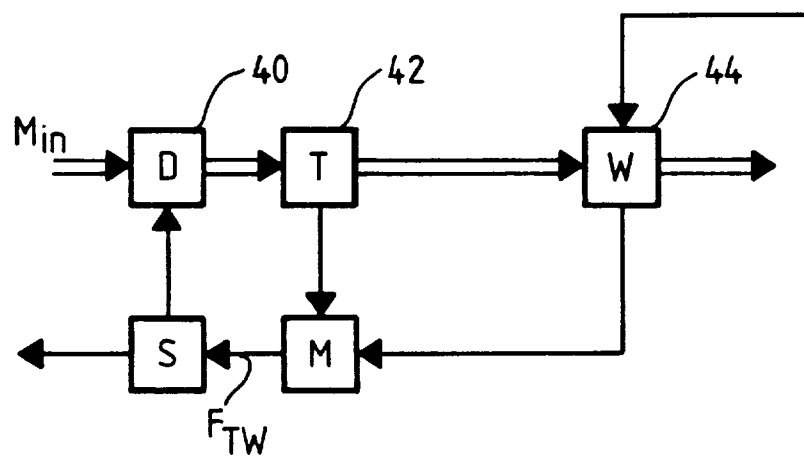


FIG.9

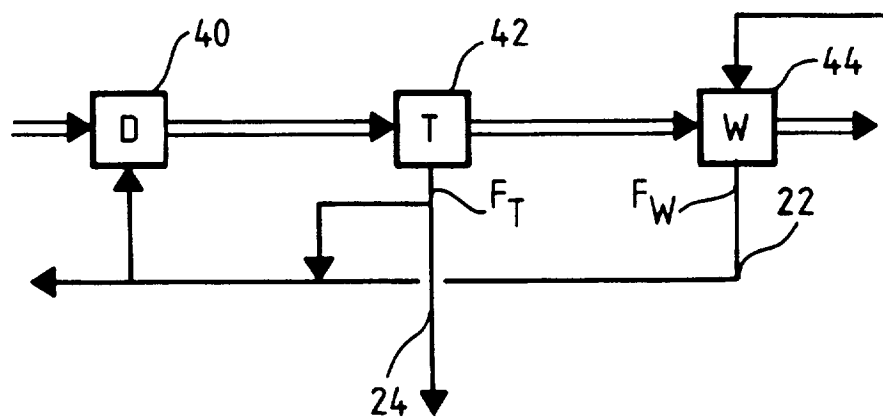


FIG.10

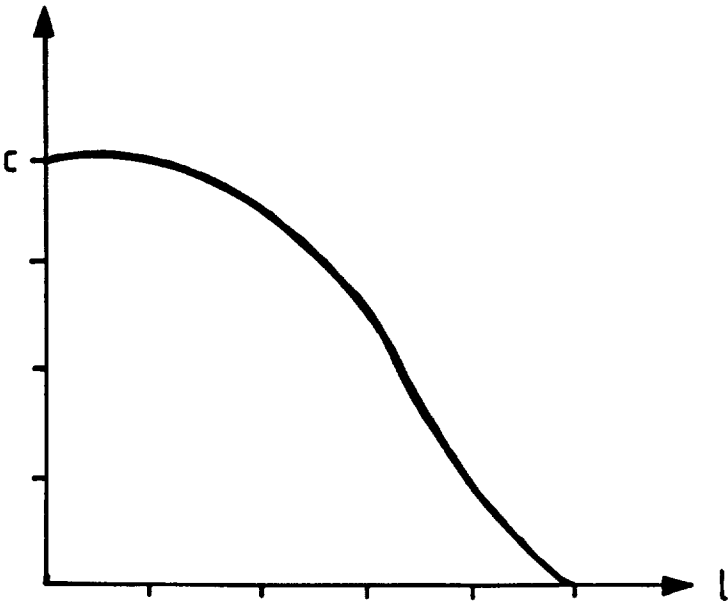


FIG.11

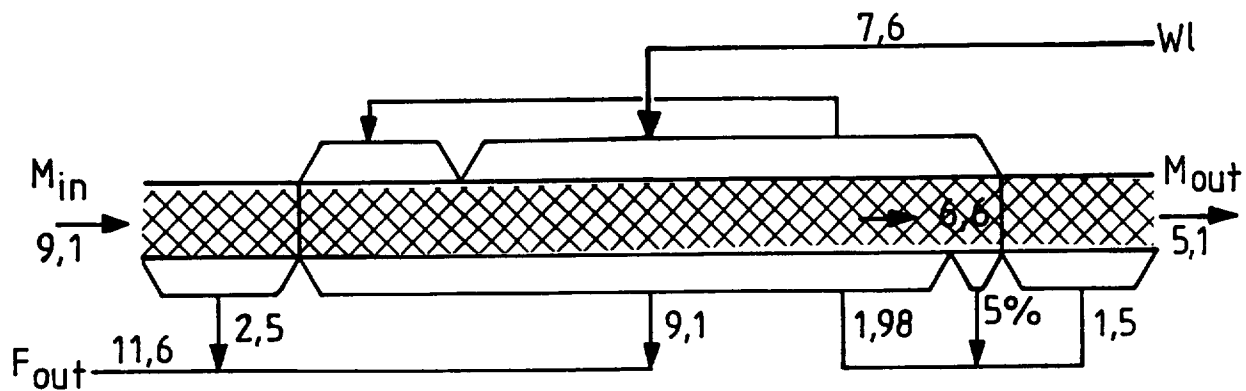


FIG. 12

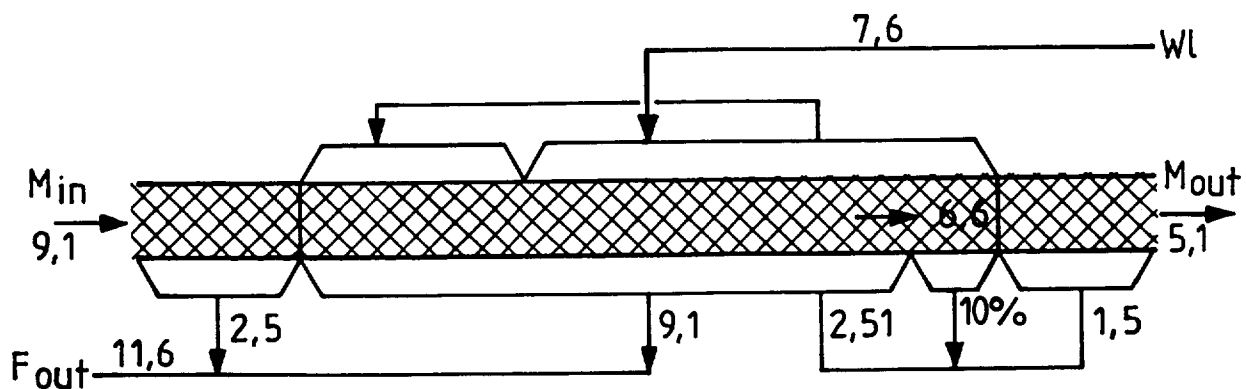


FIG. 13

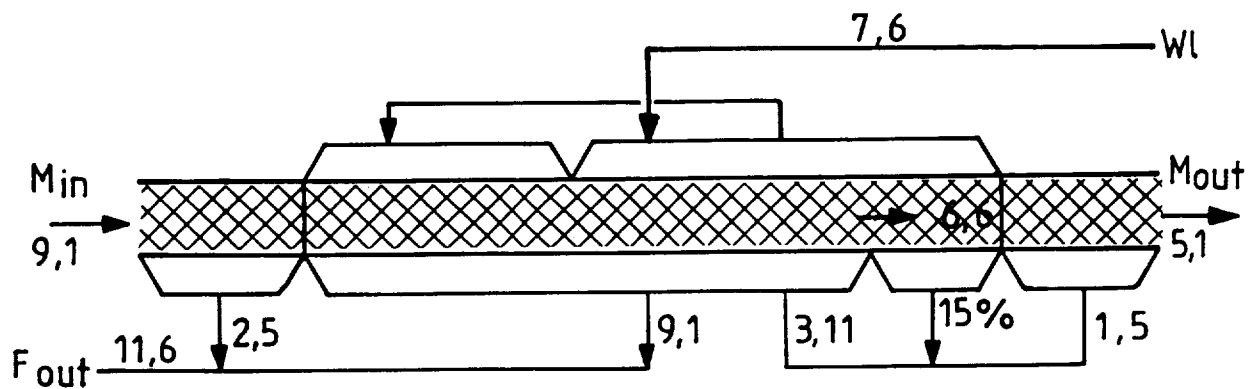


FIG. 14

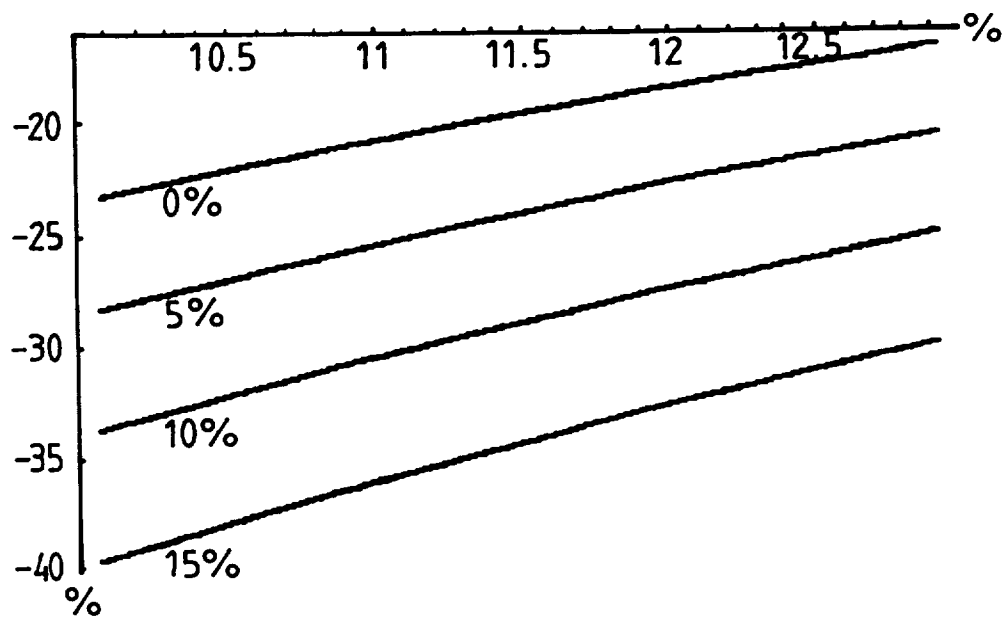


FIG. 15

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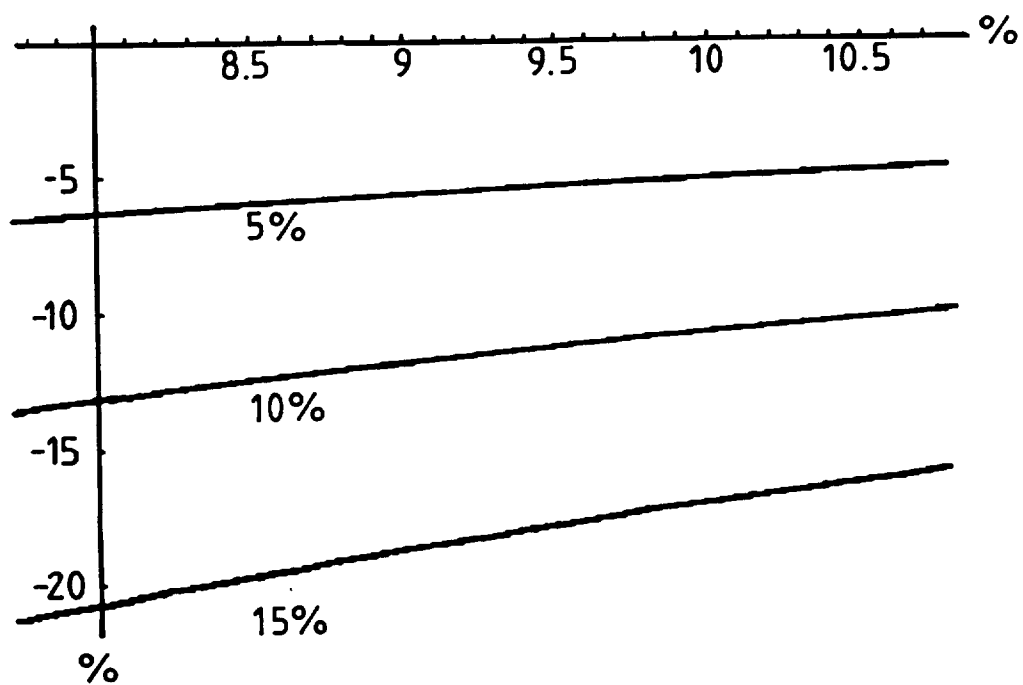


FIG. 16

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 96/00316

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21C 9/06, D21C 9/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: D21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5116423 A (SEPPO K. KOKKONEN ET AL), 26 May 1992 (26.05.92), column 4, line 61 - column 5, line 62 --	1-6,8-21
X	US 3454970 A (L.M. SUTHERLAND), 15 July 1969 (15.07.69), figure 1 -- -----	1,10-11, 14-17

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

## \* Special categories of cited documents:

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search

18 December 1996

Date of mailing of the international search report

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

PCT/FI 96/00316

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 5116423	26/05/92	EP-A,B- 0239312 SE-T3- 0239312 JP-C- 1656422 JP-B- 3020516 JP-A- 63012789 US-A- 4919158	30/09/87  13/04/92 19/03/91 20/01/88 24/04/90
US-A- 3454970	15/07/69	NONE	